

Cost As An Independent Variable

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Balancing Performance and Affordability



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Areas to be Covered

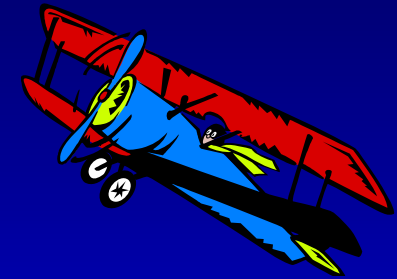
1. Background
2. Cost As an Independent Variable
3. Caiv Metrics
4. Lessons Learned

To quote Sun Tzu, The Art of War, “the wise general in his deliberations must consider both favourable and unfavourable factors. By taking into account the favourable factors, he makes his plan feasible; by taking into account the unfavourable, he may resolve the difficulties.”

CAIV and DTC

- Cost as an Independent Variable (CAIV) is a management discipline. The DOD CAIV policy sets cost as a military requirement and requires that programs establish aggressive, realistic cost objectives and to manage to obtain those objectives. Cost objectives must balance mission needs with projected out-year resources. CAIV balances cost, performance, risk, and schedule.
- Design to Cost (DTC) is an engineering discipline that meets customer cost requirements through an iterative process that balances cost, performance, and supportability while eliminating non-value added activity. DTC is an inherent element of Integrated Product Development (IPD) and is implemented within the common Integrated Product Development System (IPDS). DTC is the process of designing at product to meet a cost requirement.

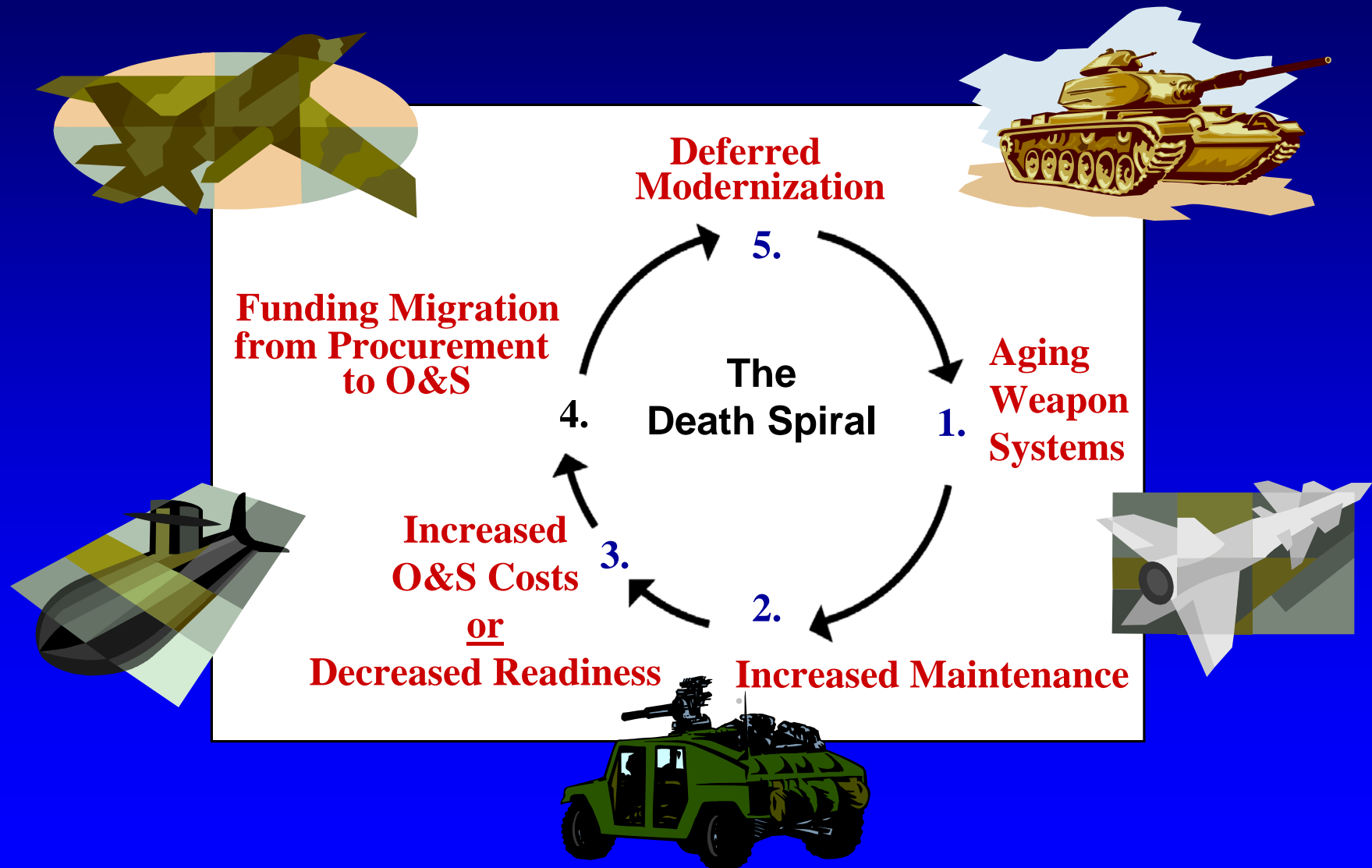
DoD's Challenge



DoD's CHALLENGE:
**HOW TO SUSTAIN AND
MODERNIZE FORCES ON
DRASTICALLY REDUCED
BUDGETS WITHOUT
"MORTGAGING THE
FUTURE TO SURVIVE?"**



The Death Spiral



CAIV and DoD

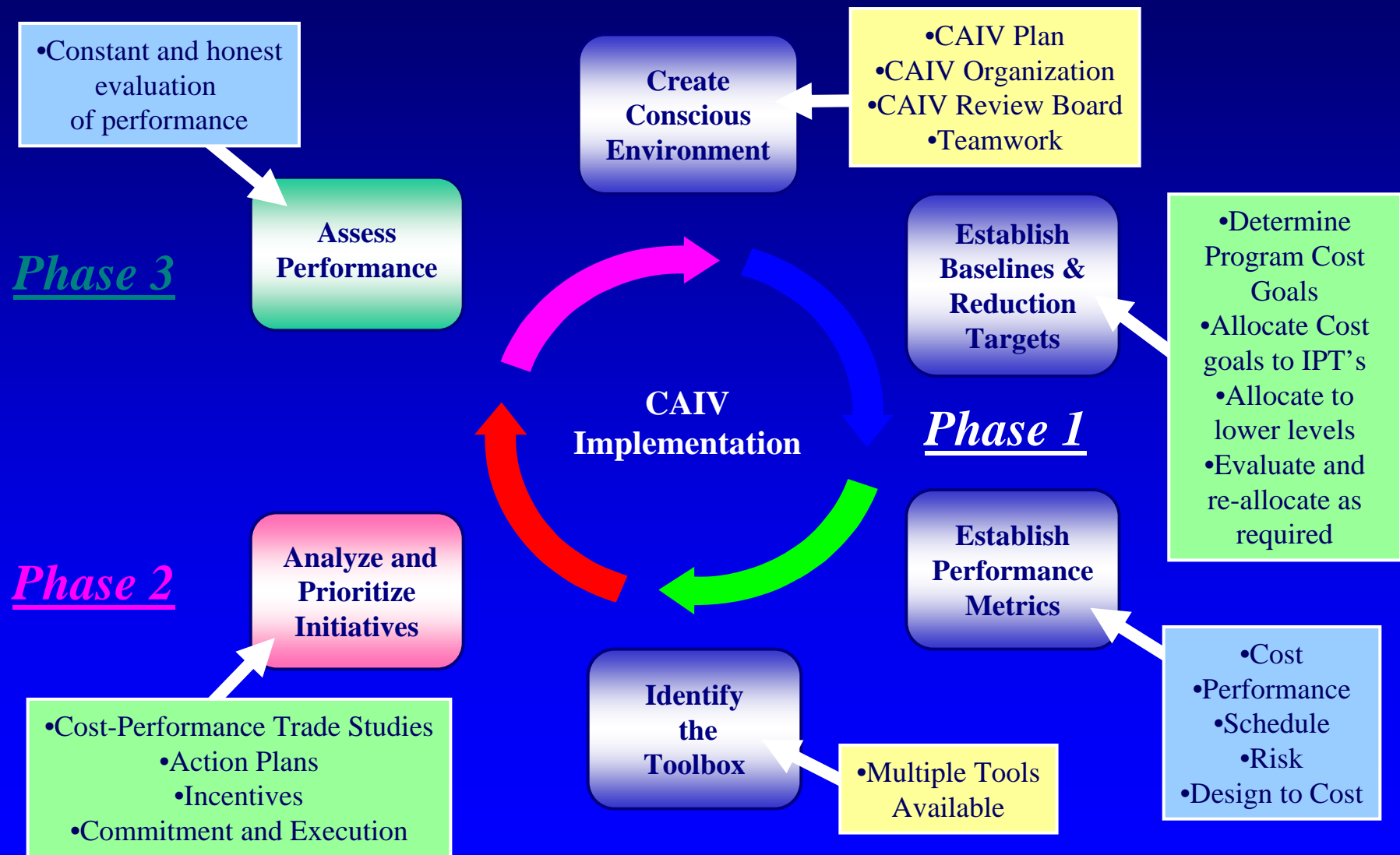
- CAIV is a DOD acquisition initiative applicable to all programs
 - CAIV assures an affordable program
 - CAIV reduces program Total Ownership Cost (TOC)
 - CAIV encompasses Design To Cost (DTC)
- Cost as an Independent Variable (CAIV): An acquisition management discipline wherein cost goals (constraints) are achieved through tradeoffs between requirements and performance.
- Tenets
 - Schedule, performance, and requirements are tradable (DoD 5000.2R)
 - Cost is treated as a constraint -- a Military Requirement (DoD 5000.2R)
 - Additional development funding may be considered an investment to reduce production and O&S cost
 - Government may establish Cost/Performance IPTs (CPIPT)
 - User participates in trade studies to determine affordable requirements
 - Risk is included in all estimates

DTC & CAIV at Raytheon Missile Systems

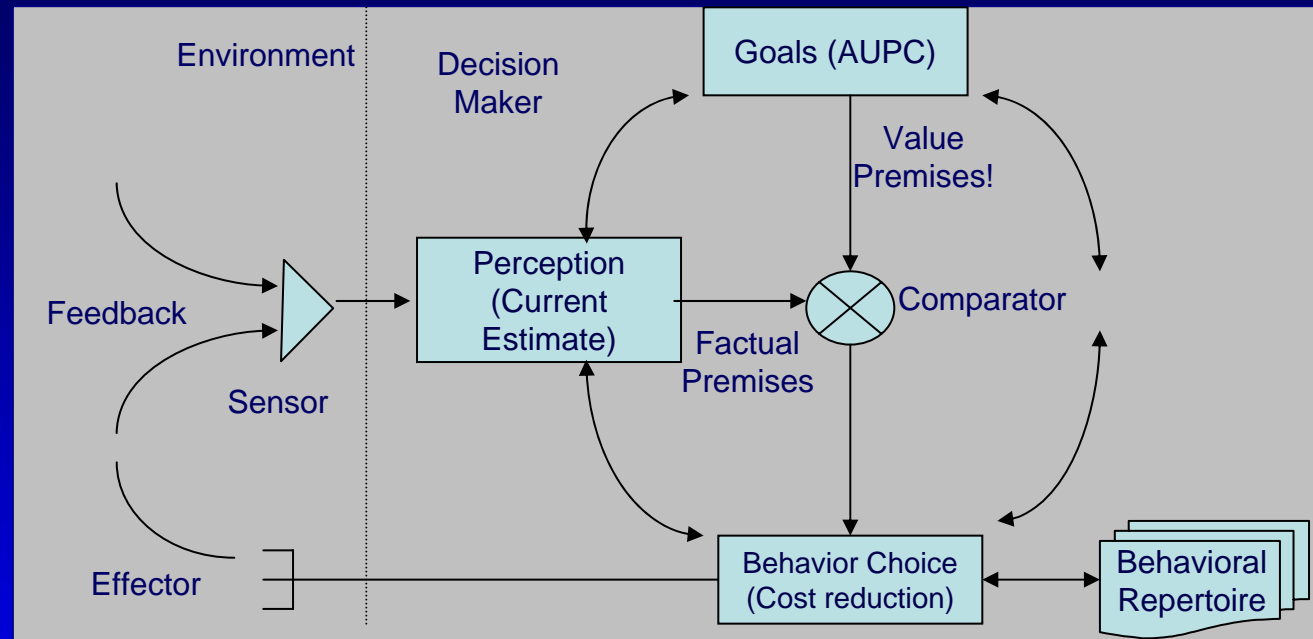
- DTC and CAIV are blended into Business Development under the heading of Affordability.
- Within the process at RMS:
 - Defined cost targets are assigned to each IPT
 - Focus is on identified cost drivers
 - Cost vs performance tradeoffs are conducted that lead to best value solutions
 - Metrics are determined and reported accordingly
- Each design choice is evaluated simultaneously for both cost and benefit
- CAIV begins before Concept Exploration and remains, with DTC, vigorous throughout product development

CAIV – Cost As an Independent Variable

CAIV Implementation and Flow



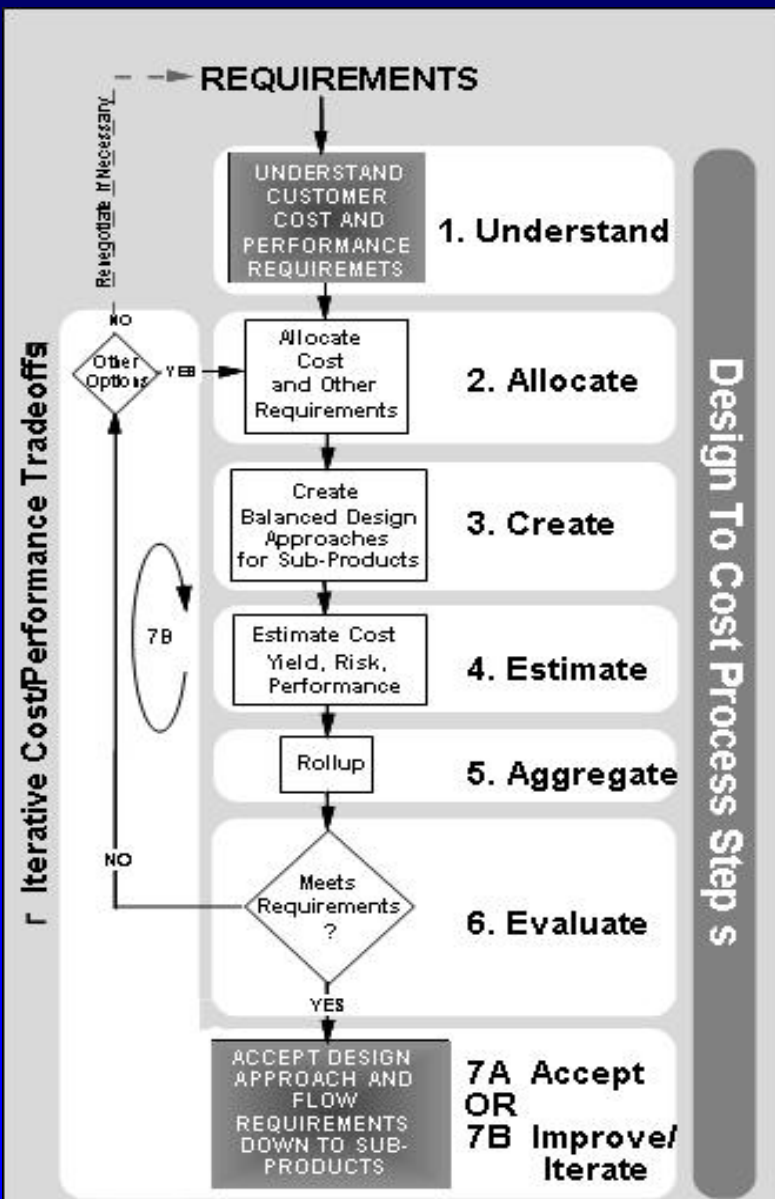
CAIV as a Management Control System



Management Control Systems are put in place to direct targeted activity toward achievement of the desired results.

Management Control Process	CAIV Process
Set goals and performance measures	Sets Cost Goal as part of Affordability Plan
Measures achievement	Prepares current cost estimate
Compares achievement with goals	Current estimate vs. Affordability Goals
Computes the variances as the result of the preceding comparison	Estimates system and subsystem variances
Reports variances	Reports \$ Data
Determines the cause(s) of the variances	Cost Drivers, spec. risk, etc.
Takes action to eliminate variances	Action plan: changes
Follow-up to ensure that goals are met	Repeats at interval per plan

Seven Steps to an Affordable Design



The engineer must use the following

7 steps to execute DTC:

1. Understand requirements
2. Analyze functions
3. Identify physical alternatives / allocate requirements / plan task
4. Design synthesis
5. Cost Modeling – Estimation & Rollup
6. Evaluate – Meet or changes requirements?
7. Select/Formalize Design

Plus, an often overlooked 8th step to:

8. Document and report progress towards meeting the cost goal.



CAIV Metrics
The Balancing Act in
Practice

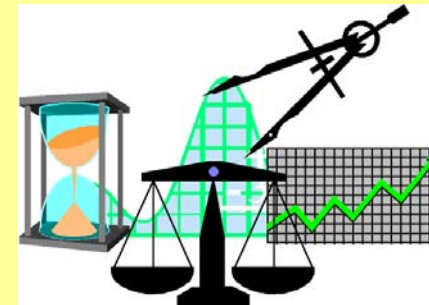


Metrics and System Engineering

An often asked question deals within what role do metrics have within the System Engineering Community.



Systems Engineering Measurement Primer



A Basic Introduction to Systems Engineering Measurement
Concepts and Use

Version 1.0

March 1998

This document was prepared by the Measurement Working Group (MWG) of the International Council on Systems Engineering (INCOSE). It was approved as an INCOSE Technical Paper by the INCOSE Technical Board.

Metrics

The purpose of any metric is to drive proper behavior.

- Proper behavior is achieved by setting, striving for, and ultimately reaching goals. A DTC metric is therefore one that keeps cost and cost reduction in the forefront.
- The proper metric for DTC is one that establishes a system cost goal for the design and that requires attainment of estimated production costs at specified points along a program timeline starting pre-SDD and going through production.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.
- The DTC metric is measured as cost variance to the required time-phased goals. Any variance to a cost goal should precipitate IPT action to eliminate the discrepancy.
- Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.

CAIV Metrics

CAIV Metrics encompass not only cost, but performance, schedule and risk as well. The primary metric to measure specific CAIV project effectiveness is cost. The utilization of this metric requires an established cost baseline in sufficient detail to compare prior and resultant impacts of a CAIV project.

Critical to the utilization of these primary metric comparisons is the need for an established baseline. Without it, comparison is meaningless.

CAIV Metric	Threshold	Goal	Current	% Current/Goal	Plan of Action
Cost					
Performance					
Schedule					

Other metrics that are used to evaluate how well a program is implementing CAIV:

- Establishment of the CAIV Team (PM, User and Contractor)
- Office personnel familiarity with the CAIV technique
- Availability of CAIV guidance
- CAIV accomplishments
- Number of CAIV Trade Studies
- CAIV database

CAIV Metrics -- An Example

CAIV Metric	Threshold	Goal	Current	Current/Goal	Risk Assess	Cost Driver	Latency	Plan of Action
Cost - System	\$ 32,775.00	\$ 31,500.00	\$ 37,790.00	1.20				
Sub-System	\$ 5,000.00	\$ 4,500.00	\$ 6,200.00	1.38			2	no
Sub-System	\$ 1,500.00	\$ 1,500.00	\$ 1,400.00	0.93			4	no
Sub-System	\$ 12,275.00	\$ 12,000.00	\$ 17,890.00	1.49			1	yes
Sub-System	\$ 8,000.00	\$ 7,500.00	\$ 6,000.00	0.80			6	yes
Sub-System	\$ 2,500.00	\$ 2,500.00	\$ 2,700.00	1.08			3	yes
Sub-System	\$ 3,500.00	\$ 3,500.00	\$ 3,600.00	1.03			2	yes
Sub-System								
Sub-System								

Performance	Requirement	Goal	Current	Req/Current	Risk Assess	Cost Driver	Latency	Plan of Action
speed mph	200	220	180	1.11			1	no
range nm	500	550	575	0.87			1	no
load lbs	750	750	900	0.83			1	no
KPP-4								

Schedule	Contract	Goal	Expected	Exp/Con	Risk Assess	Cost Driver	Latency	Plan of Action
Dates								
Months to Go	18	15	15	0.83			2	no

How much information can you get from this chart?
 Where would you concentrate efforts? What might you want to re-visit?

CAIV Metrics Sample Chart

CAIV Metrics chart at a glance:

- Discloses a program's status in the areas of cost, performance and schedule. From the above sample chart one can quickly see:
 - The program is projected to over-run costs by 20%.
 - Two of the sub-systems are in the red; one with a high risk of failing.
 - The PM has no plan of action to fix one of the red areas
 - One sub-system is in the "violet" with low risk of failure so perhaps cost goals ought to be re-allocated.
 - The others are close to goals on one-side or the other
 - Two of the performance areas have superseded requirements while one area, without a plan of action and at high risk of failure is in the red.
 - And, the program is planning on an early delivery.
- The color coding helps management key in on specific areas of concern and make necessary changes.

CAIV and DTC Reports

Part Level

Program: **Program Name** CAIV Cost Units: **K\$**
 Part / Assy: **Part 1** Engineering Report Date: _____

Cost Element Description	TARGET Cost	% Pgm Total	Current Estimate	Delta to Target	Responsible Engineer	Trend
System design cost	\$5	6%	\$5	\$0		
Digital design cost		0%	\$0	\$0		
RF, microwave & analog design cost		0%	\$0	\$0		
Mechanical design cost		0%	\$0	\$0		
Manufacturing design support cost		0%	\$0	\$0		
Software engineering cost		0%	\$0	\$0		
Support System design cost		0%	\$0	\$0		

NONRECURRING COSTS Management Report

Part/Assembly Description	NRE TARGET Cost	% Total	Current Estimate	Delta to Target	Responsible Engineer	Trend
Part 1	\$3	100%	\$6	(\$3)		
Part 2		0%	\$0	\$0		
Part 3		0%	\$0	\$0		
NRE Sub-Total						
REC Sub-Total						
Total:	\$3					

RECURRING COSTS Management Report

Part/Assembly Description	RECURRING TARGET Cost	% Total	Current Estimate	Delta to Target	Responsible Engineer	Trend	Risk
Part 1	\$1	3%	\$2	(\$1)		steady	RED
Part 2	\$2	14%	\$6	(\$4)		decreasing	RED
Part 3	\$3	17%	\$7	(\$4)		decreasing	RED
Part 4	\$4	12%	\$5	(\$1)		steady	Yellow
Part 5	\$5	12%	\$5	\$0		steady	Green
Total Material	\$15		\$20			increasing	RED
LABOR	\$4	12%	\$5	(\$1)		decreasing	Yellow
PM/SE	\$3	21%	\$9	(\$6)		increasing	RED
ODC	\$1	7%	\$3	(\$2)		decreasing	RED
Total:	\$23	100%	\$42	(\$19)			

Current Recurring Cost Estimate

Current Cost Estimate

Production Assumptions:

Total production quantity: _____
 Production rate: _____
 1st production contract quantity: _____
 Production factors similar to: _____
 Year dollars: _____

Action Items and Trade Study

1:	2:	3:	4:	5:	6:	7:	8:

Program Assumptions

- Preliminary DTUPC data prepared by _____
- Unit Production Quantity: _____
- Costs are at PCL in FY00x \$K _____
- Costs derived from _____
- Production costs for size units _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

Other Production Assumptions:

- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

Major Cost Drivers:

1:	2:	3:	4:	5:	6:	7:	8:	9:

Action Items

Action Items	Who	Assigned	Due	Status

Recurring and Non-Recurring

Program: **Program Name** CAIV Cost Units: **K\$**
 Sub-System: _____ Management Report Date: **today**

Sub System Description	TARGET Cost	% Total	Current Estimate	Delta to Target	Trend	Risk
NRE	\$3	6%	\$6	(\$3)	decreasing	RED
Material	\$15	34%	\$20	(\$5)	increasing	RED
Labor	\$4	7%	\$5	(\$1)	decreasing	Yellow
PM/SE	\$3	12%	\$9	(\$6)	increasing	RED
ODC	\$1	4%	\$3	(\$2)	decreasing	RED
3% Fridge	\$1	2%	\$1	(\$1)		
12% Overhead	\$3	8%	\$8	(\$5)		
12% PCM	\$3	9%	\$6	(\$3)		
15% G&A	\$2	5%	\$3	(\$1)		
3% COM	\$1	3%	\$2	(\$1)		
Totals:	\$39	100%	\$73	(\$34)		RED

DTUPC Price per Unit

Current	\$5.20	\$9.60	(\$4.40)
Target	\$7.89	\$14.56	(\$6.67)

Current Cost Estimate

Production Assumptions

- Preliminary DTUPC data prepared by _____
- Unit Production Quantity: _____
- Costs are at PCL in FY00x \$K _____
- Costs derived from _____
- Production costs for size units _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

Other Production Assumptions:

- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

Production Assumptions:

Total production quantity: _____
 Production rate: _____
 1st production contract quantity: _____
 Production factors similar to: _____
 Year dollars: _____

Major Cost Drivers:

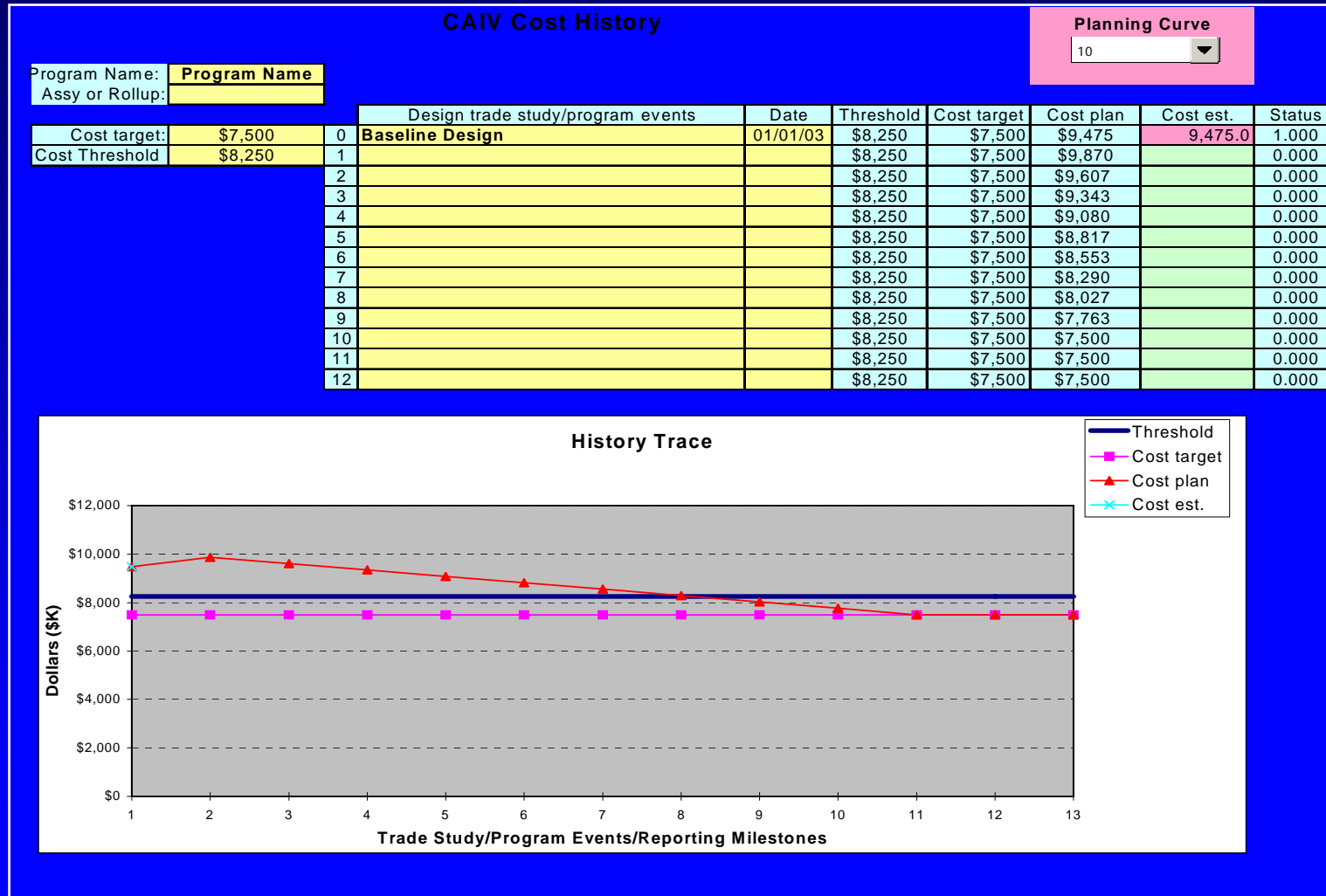
1:	2:	3:	4:	5:	6:	7:	8:	9:

Action Items

Action Items	Who	Assigned	Completed
conduct trade study to determine possible relaxation of XPP 1	Eng Name	date	date

Management Summary

CAIV and DTC Reports



Program, System, Component History Charts

Lessons Learned

Lessons Learned

- Affordability is the primary driver in all architecture design and development activities.
- CAIV requires mandatory cost requirements be assigned to all programs down to the lowest levels.
- Programs must track and measure their current design to cost status against their goals at periodic intervals. (Cost Management)
- Cost must be a design requirement with importance equal to or greater than performance.
- Cost estimation can be approximate in early program phases, progressively better during later phases.
- Proper behavior is achieved by setting, striving for, and ultimately reaching goals. CAIV metrics therefore keep cost and cost reduction in the forefront of IPT activity.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.

Any Questions?

- Now is a good time to ask.

